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NIDDESC-Enabling Product Data Exchange for Marine Industry

No. 5B-1

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The opinions expressed herein are those of the author and not necessarily those of the Department of Defense, the Department of the Navy, the National Ship building Research Program or NIDDESC member organizations.1

ABSTRACT

The use of Computer Aided Design (CAD) technology in the U.S. Navy and Marine industry has evolved from a drafting based design tool to a 3-Dimensional(3D) product oriented information base, used for design, production and service lift support. One of the most significant enhancements to current CAD technology has been the incorporation or integration of non-graphic attribute information with traditional graphics data. This expanded information base or product model has enabled the marine industry to expand CAD use to include such activities as engineering analysis, production control, and logistics support. While significant savings can be achieved through the exchange of digital product model data betwccn differ- ent agents. current graphics based CAD data exchange standards do not support this expandcd information content.

The Navy/Industry Digital Data Exchange Standards Committee(NIDDESC)wasformcdasacooperative effort of the Naval Sea Systems Command (NAVSEA) and thcNationalShipbuilding Research Program to develop an industry consensus on product data and to ensure these industry requirements arc incorporated into national and international data exchange standards. The NIDDESC effort has rcsuitcd in the development of a suite ofproduct model specifications or Application Protocols (AP's) defining marine industry product model data. These AP's have been submitted for inclusion into the next generation of data exchange standards.

NOMENCLATURE

ANSI	American National Standards Institute
AP	Application Protocol
CAD	Computer Aided Design
CALS	Computer aided Acquisition and Logisitics Support
HVAC	Heating. Ventilation. & Air Conditioning
IGES	InitiaI Graphics Exchange- Specification.
PO	IGESIPDES Organization
ISO	International Standards Organization
IWSDB	Integrated Weapon Systems Database
MIL-D-28000	DOD Specification for Digital Data Exchange.
NIAM	Nijssen's Information Analysis Method.
NIST	National Institutes of Science and Technology
PC	Personal Computer
PDES	Product Data Exchange using STEP.
STEP	STandard for the Exchange of Product data.

INTRODUCTION

The U.S. marine industry has been progressively expanding the use of Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) technology for both Naval and commercial ship design and construction. More recently, these 3D CAD/AM implementations have expanded the traditional graphics oriented applications to include associated non-graphic attribute information such as weight, material, and production control information (1).

This combination of graphic and non-graphic information known as product or product model data has become the basis of current CAD/CAM use by many in the U.S. Navy and marine industry. Several shipyards have developed design and production systems on the integration of traditional CAD/CAM systems with other informational databases. The recent NAVSEA CAD 2 system acquisition has enabled the Navy to pursue the implcmcntation ofa product model architecture for design, construction, maintenance. and modcmizuion of naval ships.

The trend toward the integration of previously separated at a base systems for design, material, fabrication, etc., has resulted in a need for better and more complex data exchange mechanisms capable of handling this expanded information base. This need is being met by the efforts of thcNavy/lndustry Digital Data Exchange Standards Committee (NIDDESC).

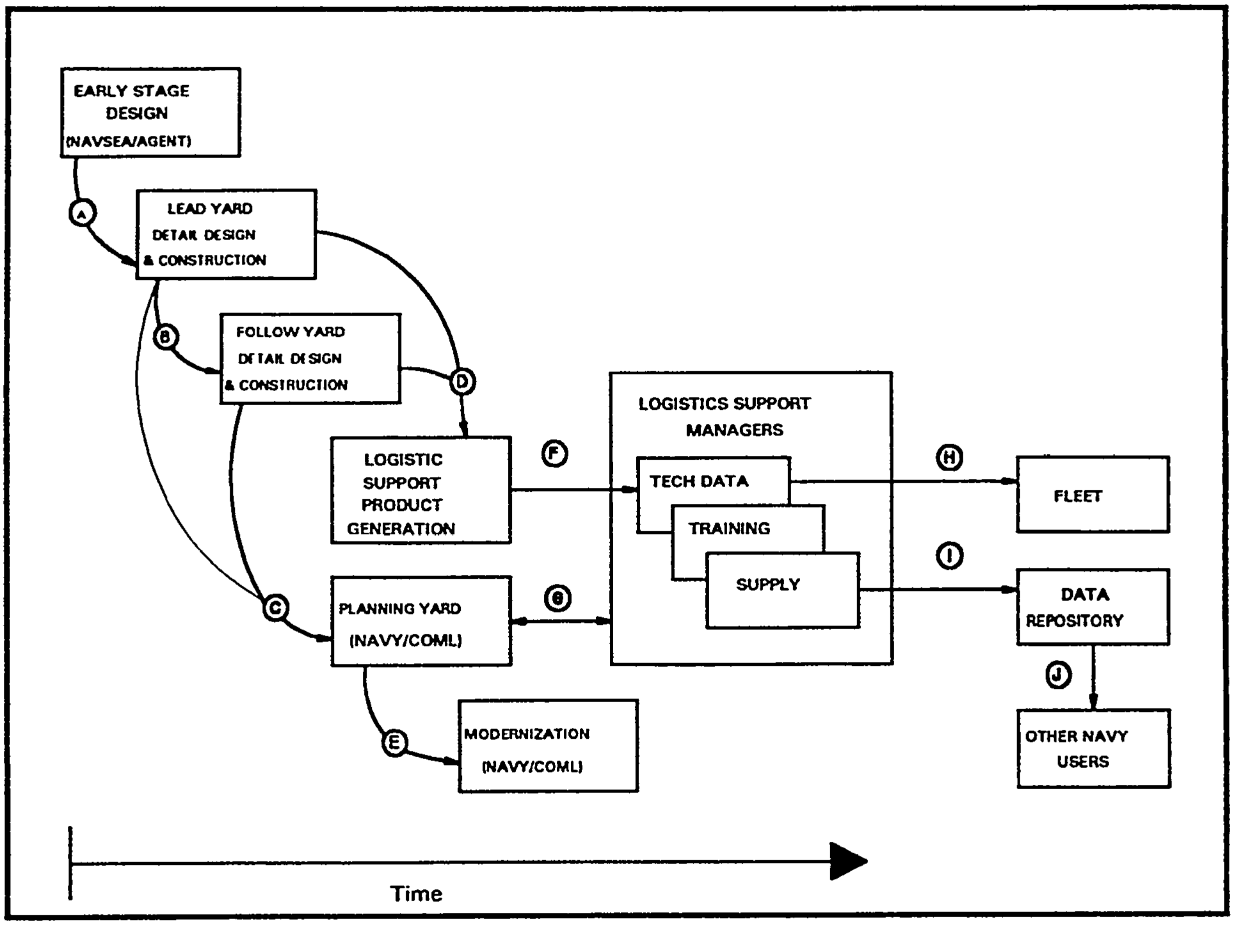

Fig. 1 Principle Data Transfer Interfaces During a Ship's Life Cycle

BACKGROUND

One of the most significant benefits associated with CAD/CAM use, is that once captured, data canbere-used at significant savings. Savings can bc accrued through the rc- use of data for design developments as well as in transferring existing data from one activity to an-other. In addition to savings accrued through there-use of digital data, further bcncfits can be achieved through the reduction of errors associated with regeneration of data and reduced time required to enter data. As most marine industry organizations have made significant investments in information technologies, the focus has begun to shift from whcthcr todevelop products in digital form to how to accomplish this goal in the most effective manner. This paper will focus on the exchangc of digital data betwccn diffrerent organizations and different computer systems.

There are in general two different digital data transfer interface types within the marine industry. The first type is between successive organizations responsible

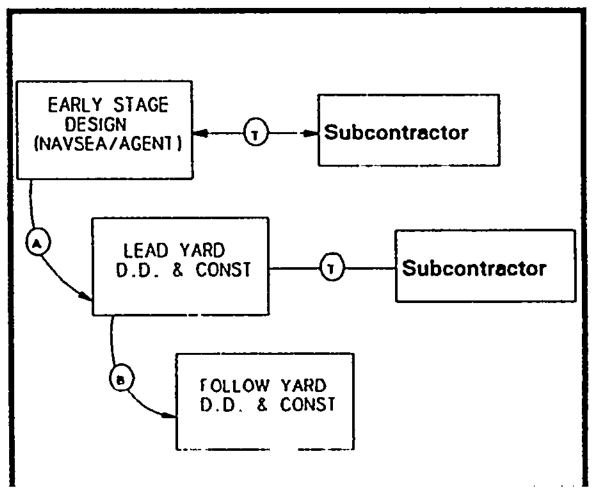

Fig. 2 Subcontractor Transfer Interface

for different aspects of a ship's life cycle such as design, fabrication or service lift support Figure 1 depicts these principle cxchange interfaces for the life cycle of U.S .Navy ships. This depiction of transfer interfaces has been used extensively by NAVSEA and others in determining re-quiremcnts and priorities for data exchange.

The second type of digital exchange occurs be-tween an organization and its subcontractors for such purposes as design support or fabrication. This inter-change enables an organization to send and/or receive digital data from supporting design contractors or to exchange digital fabrication instructions for use in Nu-merical Control (NC) machining. Figure 2 expands the previous figure to include this second exchange interface.

DATA EXCHANGE MECHANISMS

Several CAD Data exchange standard have been in use in the marine industry for the last a number ofyears. These standards arc based on the exchange of neutral file descriptions and have met with varying success. As with most CAD system databases, these exchange standards are primarily graphics oriented, concentrating on the transfer oflines, arcs,splines, text,etc.. There remain some options to enhance existing standards to incorporate additional attribute information thus enabling more of a product data transfer, but in general full product model transfer will require a next generation standard designed to handle graphic and non-graphic attribute data. A summary of existing and developing standards for digital data ex-change is provided below:

IGES

Most current CAD data exchange is via the Initial Graphics Exchange Specification (IGES). IGES is the approved ANSI standard for neutral tile transfer of CAD' graphic data and is used through out the industry. Initially developed for graphics, IGES has been enhanced or ex-pandcd to include some limited attribute information. IGES tmnsfers however, have not been without

DXF

DXF is a proprietary cxchangc format developcd and maintained by Autodesk, Inc. Primarily used in the exchange of personal Computcrbascd CADsystcmsgraph-its data. It has been used successfully for the exchange of wireframe geometry. but is not suitable for complex 3D surface and solid model cxchangcs. There is no formal revision process associated with updating or enhancing DXF as an exchange mechanism.

MIL-D-28000

MIL-D-28000 is the Computer aided Acquisition and Logistics Support (CALS) standard for the acquisition of technical data in CAD processable vector format. This military standard defines the use of IGES for Department of Defense (DOD) data acquisitions.

STEP (STANDARD FOR THE EXCHANGE OF PRODUCT DATA)

STEP is the international Standards Organiza-tion (ISO) standard for product data exchange currently under development. This next generation standard is targeted to replace IGES providing for a more robust exchange of product information.

PRODUCT MODEL ACTIVITY IN THE MARINE INDUSTRY

Several U.S. Navy ship acquisition programs have developed 3D product model databases to support the detail design, fabrication, and assembly functions. The SEAWOLF submarine and the DDG 51 class destroyer programs have made significant use of the product model approach and have exchanged this data between lead and follow shipyards. The SA'AR 5 design, developed by Ingalls shipbuilding utilizes a combination of 3D CAD and relational database technology in developing product model data.

The SEAWOLF data exchange between Newport News Shipbuilding and General Dynamics Electric Boat Division is based on the Initial Graphics Exchange Speci-fication (IGES). The SEAWOLF program enabled the exchange of significant product data through the use of IGES for graphics and project specific translation of non-graphic attribute or list type data. Limitations of the IGES specification required that both Newport News and Elec-tric Boat establish CAD modeling and data exchange procedures to ensure successful data exchange. Production transfers of piping, heating ventilation and air condition-ing (HVAC) and drawing data have been achieved on this program.

TheDDG 51 class destroyer acquisition program has made extensive use of 3Dproduct model data for detail design and fabrication purposes and planning has begun for the use of this product data for service life support. As with the SEAWOLF program, the DDG 51 exchanges product data between lead and follow builders, Bath Iron Worksand Ingalls Shipbuilding. The exchange is accom-plishcd through the transfer of a neutral tile description developed specifically for the DDG 51 program. This project specific transfer mechanism enables the transfer of additional attribute information and was developed be-cause of the inability of current exchange standards to handle the range of product data necessary fo r the DDGS1 program.

The SA'AR 5 design, developed recently by Ingalls shipbuilding was accomplished using 3D CAD

models Iinkcd to other databases containing non-graphic attribute data. This product model data has been used for interference detection. weight calculation and material take-off. (1)

With the award of the CAD 2 contract to Intergraph, NAVSEA has expanded its development and implementation of CAD systems, based on a product model architecture (3). This product model architecture will provide the foundation for the implementation of phase 3 ofthe DOD CALS program. Phase 3 CALS, orthe implementation of Integrated Weapon Systems Data Base (IWSDB). describes a 3D product model information environment containing information for design, construction, maintenance, and modernization of Naval ships.

There is an increased emphasis on the ability to exchange digital information, as NAVSEA and the U.S. Marine Industry continue to develop and utilize 3D product model data. While savings associated with the exchange of data has justified the development of project specific translation capabilities, the need for a single definition of product data and improved transfer mechanisms has been recognized. This need led to the formation of NIDDESC.

HISTORY OF THE PROGRAM

NIDDESC was formed in 1986as ajoint effort of the U.S. Navy and the National Shipbuilding Research Program (NSRP). Work activities, approved by the NIDDESC Steering committee are performed by a working group consisting of industry technical experts.

NAVY	INDUSTRY
NAVSEA 04	Bath Iron Works
NAVSEA 05	General Dynamics, E.B. Division
NAVSEA 06	Ingalls Shipbuilding
David Taylor Research Center	NASSCO
SEACOSD	Newport News Shipbuilding
Puget Sound Naval Shipyard	Angle, Inc. ’
PMS 400	Gibbs & Cox
PMS 350	The Jonathan Corporation
NAVSEA 9 1	JJH, Inc.
	Lovdahl & Assoc.
	NIST

Table I NIDDESC Member Organizations

NIDDESC member organizations participate on a cost Sharing basis with funding provided by the Navy NIDDESC member organizations include five major shipyards, several design agents, and NAVSEA representatives from different activities. The current NIDDESC member organizations are shown in Table I.

Most if not all of the member organizations have been with the program since its inception. In a cost sharing environment, this represents a significant commitment by the industry to the development of improved standards. Additional significant support and technical guidance has been provided by the Center for Building Technology at the National Institute for Standards & Technology (NISI).

CURRENT PROGRAM PLAN

The technical working group is currently completing work on the third NIDDESC program plan. This effort will result in the identification of marine industry product model content and the development of specific neutral tile format documents for incorporation into the current IGES specification and the emerging STEP standard. These documents known as application protocols AP’s) define requirements, content, and format of marine industry product data and arc required for incorporation in data exchange standards. In addition to product model information,NIDDESC has developed an AP for enhancement to the current IGES specification for the transfer of CAD drawings. Drawings remain a key document and the current IGES standard must bc further defined to ensure unambiguous transfer of this type of information.

PROGRAM PLAN # 3

The bulk of the effort of program plan#3 has been in the development and testing of STEP Application protocols. Six application protocols defining shipsproduct model data submitted for inclusion into STEP have been developed by NIDDESC. The Ship’s AP’s are for:

1. Piping,
2. Heating, Ventilation, and Air Conditioning (HVAC),
3. Electrical Distribution and Wireways.
4. structural Systems,
5. Outfit and Furnishings, and
6. Standard Parts.

In addition to STEP AP development, two additional application protocols have been defincd for the enhancement of the IGES specification. The IGES AP’s arc for:

I. Drawings, and
2. 3D Piping (submitted and approved).

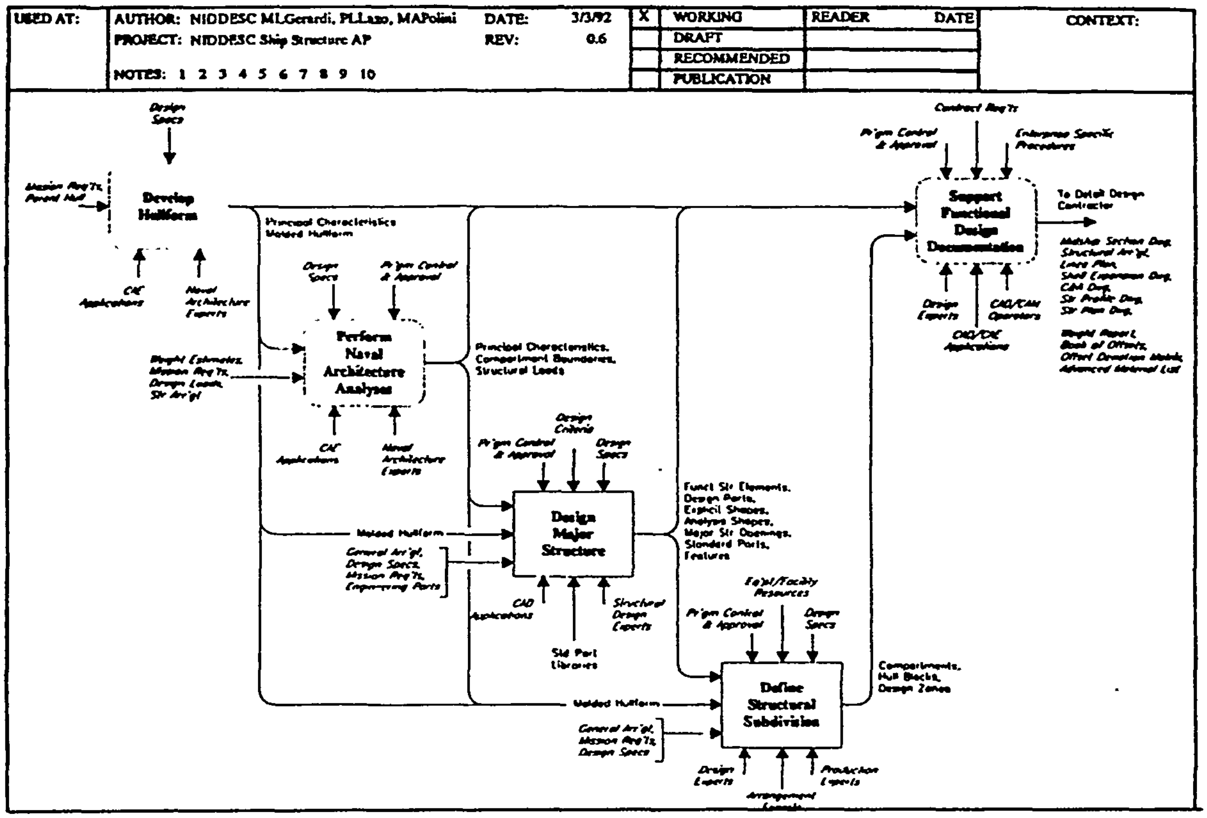

Fig. 3 Structural Functional Design Activity

IGES continues to be the primary exchange mechanism in the marine industry and it is expected be in use over the next 5 to 10 years. It is doubtful that acquisition programs initiated within the next 5 years will have any other choice but IGES, to acquire data. It may also besome time before the availability and acceptance of product data replaces the drawing as the deliverable. This expected need to exchange drawings via IGES prompted the steering committee to approve the development of an IGES drawing AP. Such an effort was required to ensure the near term exchange of drawings using IGES.

The IGES 3D piping AP was previously developed under program plan # 2. but has required extensive effort to push it through the standards process. This effort has now been included in current revision of MIL-D-28000A. While NIDDESC still pursues the development of a piping exchange within STEP, the IGES piping AP development and approval process has provided significant benefit to both NIDDESC and the IGES/PDES Organization (IPG). This document remains the only approved application protocol developcd for IGES or STEP, and currently, the only mechanism to exchange piping product model data conforming to national standards.

NIDDESC DEVELOPMENT PROCESS

The first and perhaps the most important step in the AP development process is the determination of the requirements for ship's product model data. This has been accomplished through the evaluation of the needs of the various participating organizations and on the extensive review of existing data exchange programs such as SEAWOLF and DDG 5 1.

From the assessment of industry requirements, NIDDESC determined the specific processes involved in the design, construction and life cycle support of ships. From this process evaluation, the scope and requirements for each application area is agreed upon. The IDEFO methodology is used to evaluate and define the various processes involved in a particular application area. Figure 3 provides an example of the process evaluation process using IDEFO.

This evaluation results in a defined set of functions and the products developed. For example, for the

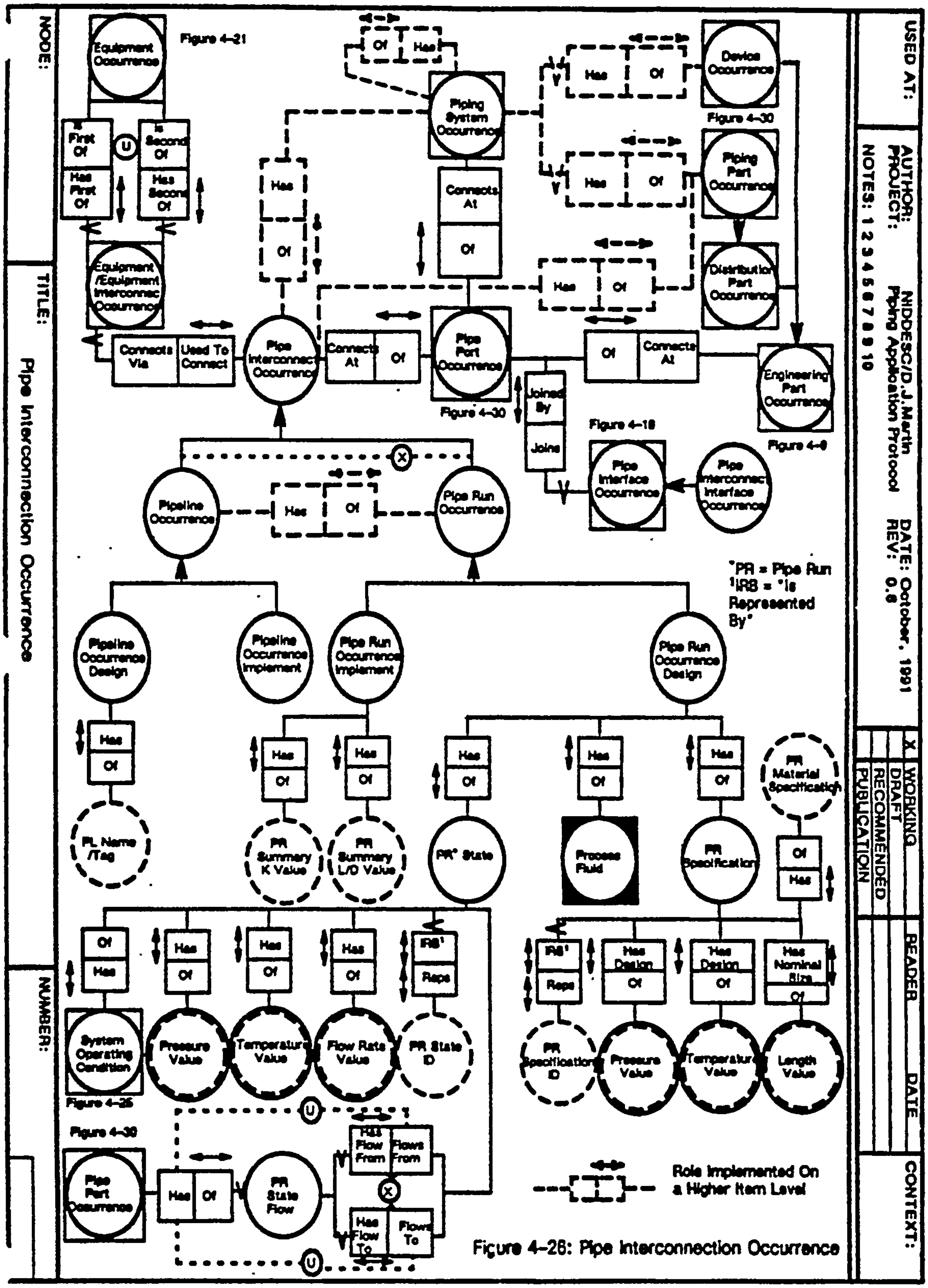

Fig 4. NIDDESC Piping Application Protocol

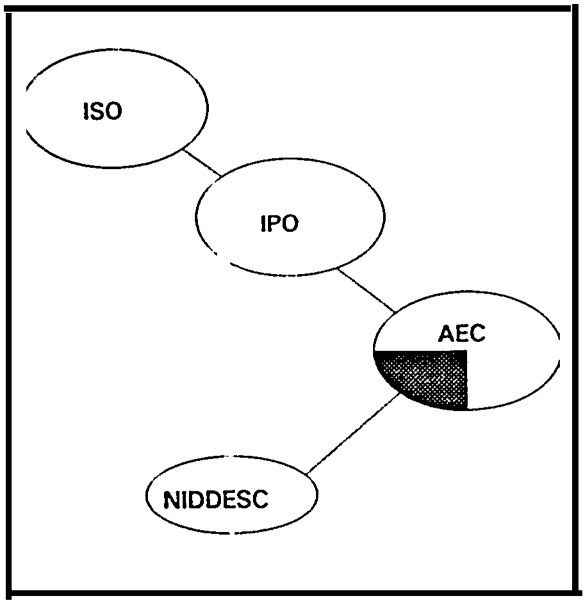

Fig. 5 Interaction Between NIDDESC, IPO & ISO

piping application these functions and products include:

- Flow Analysis,
- Equipment Arrangement,
- Piping System Test Definition,
- Interference Analysis,
- Bill of Material, and
- Pipe Stress Analysis. Etc.

From this process evaluation specific data elements and their relationships arc defined. This is accomplished through the use of Nijssen's Information Analysis Method (NIAM). This formal information modeling approach was chosen based on the functionality of NIAM to define information and its relationships found in the marine industry. Several different methods are inuse for other information modeling efforts including the IDEFIX approach. Information models define information and their relationships in terms understandable to both application and computer systems experts. Figure 4 depicts a typical NIAM model of a portion of the ship's structural information.

This marine industry development and review

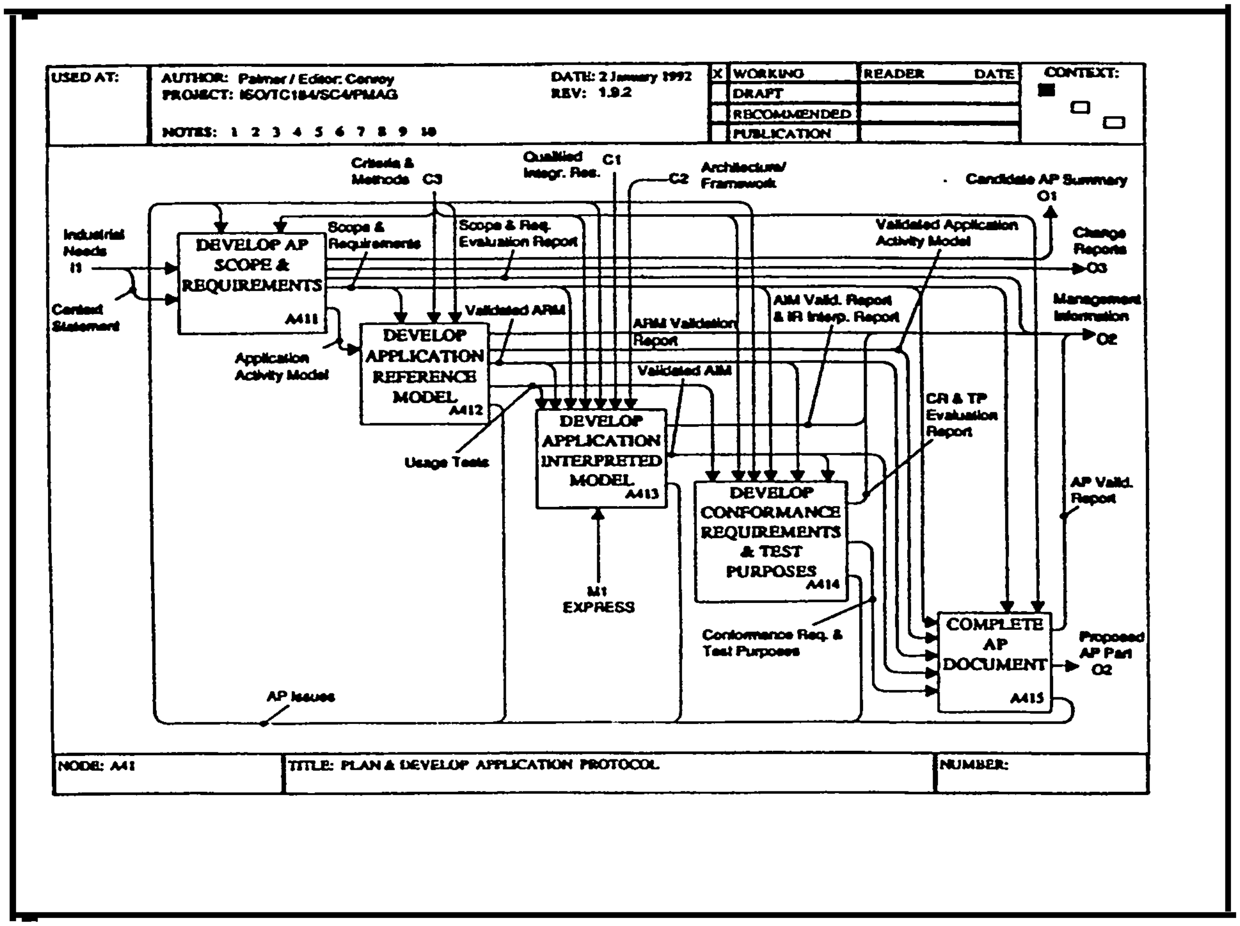

Fig. 6 STEP Application Protocol Development Process

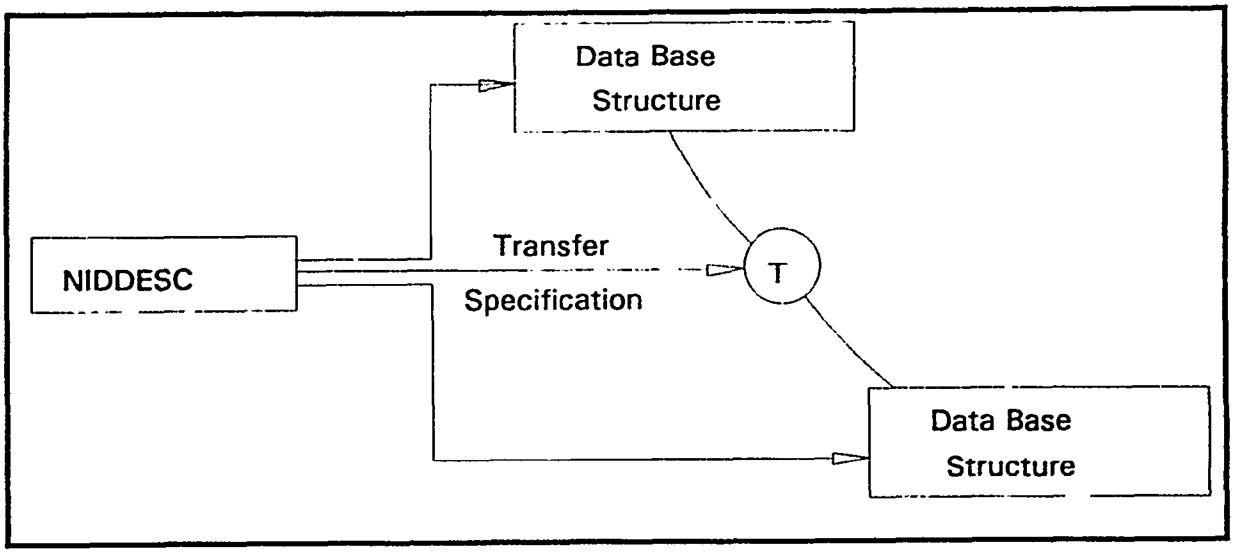

Fig. 7 Benefits of NIDDESC AP Developments

process has enabled NIDDESC to define a single product model description which will support broad industry and organization specific exchange needs. This industry agreement is key to influencing changes to national or international standards.

STANDARDS DEVELOPMENT/APPROVAL PROCESS

Once an industry's product model content is defined, an exchange standard must be developed or enhanced to incorporate this information. The United States product data standards organization is the IGES/PDES Organization within which NIDDESC works through the Architecture, Engineering Committee (AEC) sub-committee. The AEC sub-committee was chosen because of marine industry similarities between building & process plant product information, such as piping. HVAC, structures, electrical and furnishings.

Changes to the IGES specification are approved at this level by the IP0, while exchange requirements to be incorporated into STEP must be further approved by ISO. Incorporation of industry data exchange requirements into STEP requires the additional requirement of international approval. Figure 5 depicts the relationship between NIDDESC and the IPO and IS0 standards organizations.

The product data exchange standards development process is a time consuming, dynamic environment with development and approval procedures continuously changing. In particular, the STEP development and approval process is till evolving. Changing requirements placed on the participating organizations, have resulted in additional expense and have increased the uncertainty of both the timing and the actual functionality of the initial version of the standard.

Within this dynamic environment, NIDDESC strives to the maximum extent possible to adhere to the evolving guidelines for STEP development defined by the National Institute of Standards and Technology (NW') (6). Figure 6 depicts the major steps involved in the application protocol development process.

The six MDDESC application protocols have been submitted by the IPO for inclusion into the STEP standard. This represents a major milestone for the Navy and the marine industry. It is critical to long term U.S. shipyard competitiveness, that the product model exchange for ships product data be via international standards. U.S. industry must be able to communicate digitally on an international level with other organizations.

PRODUCT MODEL IMPLEMENTATION

The NIDDESC AP's will serve many purposes. In defining ships product model information, the AP's form the basis for the development of data exchange standards as well as the basis for developing or acquiring computer systems capable of dealing with this product data. Figure 7 shows this relationship.

NIDDESC has taken abroad view of the information developed during a ships life cycle and the applications to be supported in defining the scope of product model definition. Most current computer systems are not configured to utilize this information. The NIDDESC Ap's provide the information content and relationships necessary to implement product model systems. The NIDDESC product model descriptions will enable the marine industry to share a common definition of this information.

CONCLUSION

As the standards approval process continues, the navy and marine industry can now begin the integration and enhancement of current systems to acheive the benefits associated with product model exchange. With the NIDDESC standards defining product model definition, organizations can begin to plan for the exchange of 3D product data. While information systems within the industry remain different, with each organization choosing the most appropriate tool for their use, the information developed remains the same. In order to acheive the benefits of product model exchange, each must be capable of generating and utilizing this information. With the continued development of CAD systems and the enhancement of data exchange, the marine industry continues to be a leader in the product model development arena.

ACKNOWLEDGEMENT

The standards development *process* is a constantly evolving process requiring patience ,determination and a long term commitment to achieve success. The success of the NIDDESC program can be attributed directly to the individual efforts of the members the Working Group and long term commitment of the Steering Committee members. Those individuals contributing significantly to the development of NIDDESC products include: William Becker, Newport News Shipbuilding, Jack Brainin, CDNSWC, Bruce Calkins, SEACOSD, Lisa Deeds, CDNSWC, Mike Gcrardi, Bath Iron Works, Dr. Burton Gischner, General Dynamics,EB Div., Ben Kassel, CDNSWC, Dave Kinne, Bath Iron Works, Pete Laze, Newport News Shipbuilding, Rick Lovdahl. Lovdahl & Assoc., Doug Martin, NASSCO. Greg Morca, General Dynamics, EBDiv., MikePolini,JonathanCorp., Suhhash Ramachandran Angle, Inc., Virgil Rinehart, Maritime Administration, Tom Santicapita, Gibbs & Cox, Inc., Richard Shields, Ingalls Shipbuiding, Randy Stegemeyer, Puget Sound Naval Shipyard, Ron Wood, Ingalls Shipbuilding, Dan Wooley. Newport News Shipbuilding

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